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# Full-scale bioreactor pretreatment of highly toxic wastewater from styrene and propylene oxide production

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ABSTRACT

The wastewater originating from simultaneous production of styrene and propylene oxide (SPO) is classified as highly polluted with chemical oxygen demand level in the range 5965 to 9137 mg $L^{-1}$—as well as highly toxic. The dilution factor providing for a 10 percent toxic effect of wastewater samples in a test with *Paramecium caudatum* was 8.0–9.5. Biological approach for pretreatment and detoxification of the wastewater under full-scale bioreactor conditions was investigated. The number of suspended microorganisms and the clean up efficiency were increased up to $5.5–6.58 \times 10^8$ CFU $mL^{-1}$ and 88 percent, respectively during the bioreactor's operation. Isolates in the *Citrobacter*, *Burkholderia*, *Pseudomonas*, and *Paracoccus* genera were dominant in the mature suspended, as well as the immobilized microbial community of the bioreactor. The most dominant representatives were tested for their ability to biodegrade the major components of the SPO wastewater and evidence of their role in the treatment process was demonstrated. The investigated pretreatment process allowed the wastewater to be detoxified for conventional treatment with activated sludge and was closely related to the maturation of the bioreactor's microbial community.



## 1. Introduction

Currently, the petrochemical industry plays a major role in the economic growth of every nation and, in the specific case of Russia, is the recipient of major government subsidies. Its products are used in almost all industrial sectors. One typical petrochemical intermediate is styrene, which is important in rubber and plastics manufacture. For economic reasons styrene is generally co-produced together with propylene oxide. The significant use of petrochemical products results in the contamination of different ecosystems. During various stages in the production of styrene and propylene oxide (SPO), such as dehydration, dehydrogenation, and oxidation of organic compounds, highly polluted wastewater is formed. This wastewater contains volatile toxic compounds (Shokrollahzadeh et al., 2008) such as acetophenone, 1-phenyl ethanol, benzene, and phenol, as well as nonvolatile compounds such as mono- and dipropylene glycol, propanol, etc. The chemical oxygen demand (COD) of petrochemical wastewaters is typically very high. In multiple studies from different sites it has variously been estimated as 1620–1896 mg $L^{-1}$ (Calheiros et al., 2009), 2500–4100 mg $L^{-1}$ (Wei et al., 2010), and 2200–4700 mg $L^{-1}$ (Chang et al., 2011). Currently, pollution of the environment by hazardous chemical compounds is one of the most important problems (Mantis et al., 2005). Those petrochemical wastewaters need to be treated before discharging into the environment to avoid river, soil, and air pollution (Stromgren et al., 1995; Chen et al., 1998; Jerez et al., 2002; Chen et al., 2003).

Industrial wastewater treatment methods can be divided into two main groups, physicochemical and biological. Most wastewater treatment processes rely on the use of activated sludge (Soddell and Seviour, 1990; Amann et al., 1998; Blackall et al., 1998; Yang et al., 2011), due to its considerably lower cost in comparison with the physicochemical method, and reasonable efficiency (Shokrollahzadeh et al., 2008; Babaee et al., 2010; Chang et al., 2011). However, some organic substances produced during chemical production are toxic or resistant to biological treatment in conventional biological processes (Adams et al., 1996; Pulgarin and Kiwi, 1996; García et al., 2001; Lapertot et al., 2006; Muñoz and Guieysse, 2006). Meanwhile, the use of chemical and physical techniques requires very expensive pretreatment, usually results in the production of secondary effluent (Sangave et al., 2007) and does not always reduce the pollutant concentration to acceptable levels, necessitating further pretreatment before the water is finally treated with conventional activated sludge (CAS) (Babaee et al., 2010).

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